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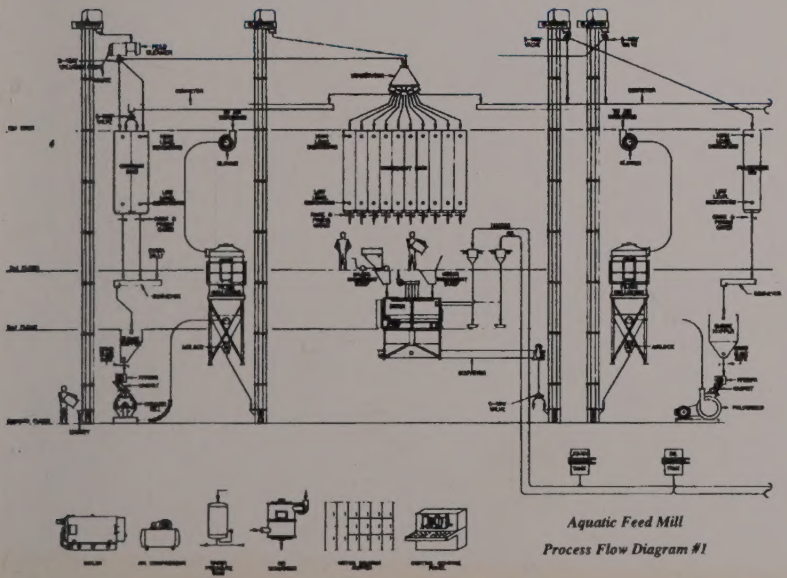
5

Suppl. 1

# AQUACULTURE DEVELOPMENT

## 1. GOOD AQUACULTURE FEED MANUFACTURING PRACTICE



*Aquatic Feed Mill*
*Process Flow Diagram #1*

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Suppl. 1

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# AQUACULTURE DEVELOPMENT

## 1. GOOD AQUACULTURE FEED MANUFACTURING PRACTICE

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2001

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## PREPARATION OF THIS DOCUMENT

The present Guidelines have been prepared by the Fisheries Department of FAO. The first drafts were written by Q. Dick Stephen-Hassard (consultant) and Albert G.J. Tacon (formerly Fishery Resources Officer within the Inland Fishery Resources and Aquaculture Service of FAO), who both served on the Secretariat for the FAO Expert Consultation on Animal Feeding and Food Safety held in Rome from 10 to 14 March 1997; the consultation produced the first FAO Draft Code of Practice for Good Animal Feeding (FAO, 1998. Animal Feeding and Food Safety. *FAO Food and Nutrition Paper 69*. FAO, Rome, 48p)[1/].

The Guidelines represent an international collaborative effort with information drawn from Asia, Europe, North America, South America and Africa. The draft Guidelines were first presented in February 1998 at the Annual International Conference and Exhibition of the World Aquaculture Society in Las Vegas, Nevada (USA), and in March 1998 at the Second Conference of the Feed Manufacturers of the Mediterranean in Reus, Spain. A shortened Working Paper entitled *Draft Technical Guidelines for Good Aquaculture Feed Manufacturing Practice* was then published within the International Aquafeed Directory and Buyers Guide 1999 (Turret Rai PLC, Uxbridge, U.K.) for wider distribution. On the basis of the comments received on the working paper (and with the additional technical assistance of Warren G. Dominy and Susan Frazer-Dominy of The Oceanic Institute, USA), a revised second draft was then sent in March 2001 to over 200 representatives of the aquafeed and feed manufacturing industry (including related allied industries such as feed ingredient suppliers, feed manufacturing equipment suppliers, and aquaculture producer associations) in over 50 countries within all the major regions of the world. The present Guidelines have been finalised with due consideration to the responses received.

The present Guidelines are preliminary and will be evaluated and revised as information becomes available through their use in support of Article 9 of the FAO Code of Conduct for Responsible Fisheries (CCRF) concerning Aquaculture Development, and in particular in support of Article 9.4.3 of the CCRF concerning the selection and use of feeds and additives (FAO, 1997. Aquaculture development. *FAO Technical Guidelines for Responsible Fisheries* No.5. FAO, Rome. 40p)[2/].

[1/] http://www.fao.org/WAICENT/FAOINFO/ECONOMIC/ESN/animal/animapdf/contents.htm
[2/] http://www.fao.org/WAICENT/FAOINFO/FISHERY/agreem/codecond/codecon.htm

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## ABSTRACT

The paper presents technical guidelines for good aquaculture feed manufacturing practice. The guidelines were compiled for FAO in support of Article 9 of the Code of Conduct for Responsible Fisheries (CCRF) concerning Aquaculture Development (FAO, 1997), and in particular in support of Article 9.4.3 of the CCRF concerning the selection and use of feeds and additives. The guidelines cover a number of issues, ranging from ingredient purchasing, processing, bulk storage, handling, monitoring, and documentation, to issues such as employee training and safety, customer relations, and the delivery of finished goods to the farmer. However, issues relating to the handling and management of manufactured aquaculture feeds by farmers on the farm are not covered here, as these will be considered within separate guidelines to be produced at a later date concerning good on-farm feed management practices.

Key words: Aquaculture, aquafeed, quality assurance, ingredients, purchasing, manufacturing, storage.

## CONTENTS

Page

BACKGROUND vii
1. INTRODUCTION ..... 1
2. STATEMENT OF PURPOSE ..... 1
3. DEFINITIONS ..... 2
4. OVERVIEW OF AQUACULTURE FEED MANUFACTURING ..... 5
5. SITE LOCATION AND DESIGN OF THE MANUFACTURING FACILITIES ..... 7
6. SELECTION AND PURCHASING OF RAW INGREDIENTS, INCLUDING INGREDIENT QUALITY CONTROL ..... 8
7. RECEIVING OF INGREDIENTS ..... 10
8. STORAGE AND HANDLING OF INGREDIENTS AND FINISHED GOODS ..... 12
9. FEED INGREDIENT PROCESSING ..... 13
10. FEED FORMULATION AND MANUFACTURING ..... 15
11. PACKAGING AND LABELLING ..... 17
12. WAREHOUSING AND SHIPPING ..... 18
13. SAMPLING METHODS AND ANALYSES ..... 19
14. RECALLING DEFECTIVE OR MISLABELLED PRODUCT ..... 20
15. PLANT CLEANLINESS AND WORKER SAFETY; HOUSEKEEPING ..... 21
16. PLANT MAINTENANCE AND REPAIR ..... 22
17. PERSONNEL ..... 23
18. DOCUMENTATION ..... 24
19. REFERENCES ..... 25
APPENDIX I: OUTLINE OF PROCEDURE FOR A PRODUCT RECALL ..... 33
APPENDIX II: PRODUCT AND PERFORMANCE INVESTIGATIONS AND CHECKLIST ..... 37
APPENDIX III: PREVENTIVE MAINTENANCE IN THE FEED MILL ..... 41
APPENDIX 1V: DRAFT CODE OF PRACTICE FOR GOOD ANIMAL FEEDING (FAO, 1998) ..... 45

## BACKGROUND

From ancient times, fishing has been a major source of food for humanity and a provider of employment and economic benefits to those engaged in this activity. However, with increased knowledge and the dynamic development of fisheries, it was realized that living aquatic resources, although renewable, are not infinite and need to be properly managed, if their contribution to the nutritional, economic and social well being of the growing world's population was to be sustained.

The adoption in 1982 of the United Nations Convention on the Law of the Sea provided a new framework for the better management of marine resources. The new legal regime of the oceans gave coastal States rights and responsibilities for the management and use of fishery resources within the areas of their national jurisdiction, which embrace some 90 percent of the world's marine fisheries.

In recent years, world fisheries have become a dynamically developing sector of the food industry, and many States have striven to take advantage of their new opportunities by investing in modern fishing fleets and processing factories in response to growing international demand for fish and fishery products. It became clear, however, that many fisheries resources could not sustain an often-uncontrolled increase of exploitation.

Clear signs of over-exploitation of important fish stocks, modifications of ecosystems, significant economic losses, and international conflicts on management and fish trade threatened the long-term sustainability of fisheries and the contribution of fisheries to food supply. Therefore, the Nineteenth Session of the FAO Committee on Fisheries (COFI), held in March 1991, recommended that new approaches to fisheries management embracing conservation and environmental, as well as social and economic, considerations were urgently needed. FAO was asked to develop the concept of responsible fisheries and elaborate a Code of Conduct to foster its application.

Subsequently, the Government of Mexico, in collaboration with FAO, organized an International Conference on Responsible Fishing in Cancún in May 1992. The Declaration of Cancún endorsed at that Conference was brought to the attention of the UNCED Summit in Rio de Janeiro, Brazil, in June 1992, which supported the preparation of a Code of Conduct for Responsible Fisheries. The FAO Technical Consultation on High Seas Fishing, held in September 1992, further recommended the elaboration of a Code to address the issues regarding high seas fisheries.

The One Hundred and Second Session of the FAO Council, held in November 1992, discussed the elaboration of the Code, recommending that priority be given to high seas issues and requested that proposals for the Code be presented to the 1993 session of the Committee on Fisheries.

The Twentieth Session of COFI, held in March 1993, examined in general the proposed framework and content for such a Code, including the elaboration of guidelines, and endorsed a time frame for the further elaboration of the Code. It also requested FAO to prepare, on a "fast track" basis, as part of the Code, proposals to prevent reflagging of fishing vessels which

affect conservation and management measures on the high seas. This resulted in the FAO Conference, at its Twenty-seventh Session in November 1993, adopting the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, which, according to FAO Conference Resolution 15/93, forms an integral part of the Code.

The Code was formulated so as to be interpreted and applied in conformity with the relevant rules of international law, as reflected in the United Nations Convention on the Law of the Sea, 1982, as well as with the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, 1995, and in the light of, inter alia, the 1992 Declaration of Cancún and the 1992 Rio Declaration on Environment and Development, in particular Chapter 17 of Agenda 21.

The development of the Code was carried out by FAO in consultation and collaboration with relevant United Nations Agencies and other international organizations, including non-governmental organizations.

The Code of Conduct consists of five introductory articles: Nature and Scope; Objectives; Relationship with Other International Instruments; Implementation, Monitoring and Updating and Special Requirements of Developing Countries. These introductory articles are followed by an article on General Principles, which precedes the six thematic articles on Fisheries Management, Fishing Operations, Aquaculture Development, Integration of Fisheries into Coastal Area Management, Post-Harvest Practices and Trade, and Fisheries Research. As already mentioned, the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas forms an integral part of the Code.

The Code is voluntary. However, certain parts of it are based on relevant rules of international law, as reflected in the United Nations Convention on the Law of the Sea of 10 December 1982. The Code also contains provisions that may be or have already been given binding effect by means of other obligatory legal instruments amongst the Parties, such as the Agreement to Promote Compliance with Conservation and Management Measures by Fishing Vessels on the High Seas, 1993.

The Twenty-eighth Session of the Conference in Resolution 4/95 adopted the Code of Conduct for Responsible Fisheries on 31 October 1995. The same Resolution requested FAO inter alia to elaborate appropriate technical guidelines in support of the implementation of the Code in collaboration with members and interested relevant organizations.

## 1. INTRODUCTION

- These technical guidelines for good aquaculture feed manufacturing practice have been prepared for the Fisheries Department of FAO in support of Article 9 of the Code of Conduct of Conduct for Responsible Fisheries (CCRF) concerning Aquaculture Development (FAO, 1997), and in particular in support of Article 9.4.3 of CCRF concerning the selection and use of feeds and additives.

- The objective of these guidelines is to encourage adherence to Good Manufacturing Practice (GMP) during the procurement, handling, storage, processing, and distribution of compound aquaculture feeds for farmed aquatic animals.

## 2. STATEMENT OF PURPOSE

- Feed millers must recognize their responsibility to provide quality products to their customers, and their intent should be to provide consistent quality products by implementing sound quality control procedures.

- Assuring quality is a direct responsibility of all feed mill employees, and each will be held accountable to follow accepted procedures to implement effective Good Manufacturing Practice (GMP) for the production of manufactured aquaculture feeds.

- Quality aquafeeds can only be made from the use of quality feed ingredient sources, and not from the use of inferior, spoiled, or otherwise damaged or contaminated ingredients; the protection of both human and animal health also being prime considerations in the production of quality cost-effective aquafeeds. (D'Mello, 2001; Machin, 2001).

- Training and assistance are vital for both new and experienced employees in order to handle tasks and solve problems in a manner that assures the manufacture of consistent high quality feed products. Each mill employee should expend the effort necessary to implement this program because quality assurance is vital to the effectiveness of the aquafeeds being manufactured and, thereby, the company's success.

- It is also the feed miller's responsibility to instruct the farmer, through label instructions and technical literature and instruction, the correct method of handling and application of the aquafeed for the particular species and farming system for which it is intended (Davis, 2001).

- The feed manufacturer should be dedicated to its customers and employees in stating its commitment to good manufacturing practices and carrying out an on-going programme to improve feed product performance and to minimize environmental impacts.

- To the extent practicable the feed manufacturer should work with producers (farmers) not only to enhance production, but also to improve aquacultural practices which may have adverse environmental or other impacts (Davis, 2001).

## 3. DEFINITIONS

- **Additive:** An ingredient or combination of ingredients added to the basic feed mix or parts thereof to fulfil a specific need. Usually used in micro quantities and requires careful handling and mixing (AAFCO, 2000).

- **Complete feed:** A nutritionally adequate feed for animals other than man: by specific formula is compounded to be fed as the sole ration and is capable of maintaining life and/or promoting production without any additional substance being consumed except water (AAFCO, 2000).

- **Compound feed:** A mixture of products of vegetable or animal origin in their natural state, fresh or preserved, or products derived from the industrial processing thereof, or organic or inorganic substances, whether or not containing additives, for oral feeding in the form of a complete feed (HMSO, 1992; see also formula feed).

- **Concentrate:** A feed used with another to improve the nutritive balance of the total and intended to be further diluted and mixed to produce a supplement or a complete feed (AAFCO, 2000).

- **Conditioned, conditioning:** (Process) Having achieved pre-determined moisture characteristics and/or temperature of ingredients or a mixture of ingredients prior to further processing (AAFCO, 2000).

- **Cooked, cooking:** (Process) Heated in the presence of moisture to alter chemical and/or physical characteristics or to sterilize (AAFCO, 2000).

- **Crumbled, crumbling:** (Process) Pellets reduced to granular form (AAFCO, 2000).

- **Date of Manufacture:** The date on which the food becomes the product as described (FAO/WHO, 1999).

- **Date of Packaging:** The date on which the food is placed in the immediate container in which it will be ultimately sold (FAO/WHO, 1999).

- **Diet:** Feed ingredients or mixture of ingredients including water, which is consumed by animals (AAFCO, 2000).

- **Diluent:** (Physical form) An edible substance used to mix with and reduce the concentrate of nutrients and/or additives to make them more acceptable to animals, safer to use, and more capable of being mixed uniformly in a feed. (It may also be a carrier) (AAFCO, 2000).

- **Expanded, expanding:** (Process) Subjected to moisture, pressure, and temperature to gelatinize the starch portion. When extruded, its volume is increased, due to abrupt reduction in pressure (AAFCO, 2000).

- **Extruded:** (Process) A process by which feed has been pressed, pushed, or protruded through orifices under pressure (AAFCO, 2000).

- **Farm-Made Aquafeeds:** Feeds in pellet or other forms, consisting of one or more artificial and/or natural feedstuffs, produced for the exclusive use of a particular farming activity, not for commercial sale or profit (New, Tacon & Csavas, 1995).

- **Feed (s):** Edible materials(s) which are consumed by animals and contribute energy and/or nutrients to the animals diet. (Usually refers to animals rather than man (AAFCO, 2000).

- **Fish Meal :** (Feed Ingredient) Fish meal is the clean, dried, ground tissue of undecomposed whole fish or fish cuttings, either or both, with or without the extraction of part of the oil. It must contain not more than 10% moisture. If it contains more than 3% salt (NaCl), the amount of salt must constitute a part of the brand name, provided that in no case must the salt content of this product exceed 7% (AAFCO, 2000).

- **Food:** Any substance, whether processed, semi-processed or raw, which is intended for human consumption, and includes drinks, chewing gum and any substance which has been used in the manufacture, preparation or treatment of 'food' but does not include cosmetics or tobacco or substances used only as drugs (FAO/WHO, 1999).

- **Formula feed:** Two or more ingredients proportioned, mixed and processed according to specifications (AAFCO, 2000).

- **Gelatinized, gelatinizing:** (Process) Having had the starch granules completely ruptured by a combination of moisture, heat and pressure, and in some instances, by mechanical shear (AAFCO, 2000).

- **Ground, grinding:** (Process) Reduced in particle size by impact, shearing or attrition (AAFCO, 2000).

- **Hazard:** A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect (FAO/WHO, 1997a).

- **HACCP:** Hazard analysis critical control point. A system which identifies, evaluates, and controls hazards which are significant for food safety (FAO/WHO, 1997a).

- **Heat-processed, heat-processing:** (Process) Subjected to a method of preparation involving the use of elevated temperatures with or without pressure (AAFCO, 2000).

- **Ingredient, feed ingredient:** Means a component part or constituent of any combinations or mixture making up a commercial feed (AAFCO, 2000).

- **Irradiated, irradiating:** (Process) Treated, prepared, or altered by exposure to a specific radiation (AAFCO, 2000).

- **Label:** Any tag, brand, mark, pictorial or other descriptive matter, written, printed, stencilled, marked, embossed or impressed on, or attached to, a container of food (FAO/WHO, 1999).

- **Labelling:** Any written, printed or graphic matter that is present on the label, accompanies the food, or is displayed near the food, including that for the purpose of promoting its sale or disposal (FAO/WHO, 1999).

- **Mash:** (Physical form) A mixture of ingredients in meal form (AAFCO, 2000).

- **Meal:** (Physical form) An ingredient which has been ground or otherwise reduced in particle size (AAFCO, 2000).

- **Medicated feed:** Any feed which contains drug ingredients intended or presented for the cure, mitigation, treatment, or prevention of disease of animals other than man or which contains drug ingredients intended to affect the structure or any function of the body of animals other than man (AAFCO, 2000).

- **Micro-ingredients:** Vitamins, minerals, antibiotics, drugs, and other materials normally required in small amounts and measured in milligrams, micrograms or parts per million (ppm) (AAFCO, 2000).

- **Pellets:** (Physical form) Agglomerated feed formed by compacting and forcing through die openings by a mechanical process (AAFCO, 2000).

- **Pelleted, pelleting:** (Process) Having agglomerated feed by compaction and forced through die openings (AAFCO, 2000).

- **Premix:** A uniform mixture of one or more micro-ingredients with diluent and/or carrier. Premixes are used to facilitate uniform dispersion of micro-ingredients in a larger mix (AAFCO, 2000).

- **Premixing:** (Process) The preliminary mixing of ingredients with diluents and/or carriers (AAFCO, 2000).

- **Ration:** The amount of the total feed which is provided to one animal over a 24 hour period (AAFCO, 2000).

- **Risk:** A risk is an estimate of the probability and severity of the adverse health effects in exposed populations, consequential to hazards in food (FAO/WHO, 1997b).

- **Risk Management:** The process of weighing policy alternatives in the light of the results of risk assessment and, if required, selecting and implementing appropriate control options, including regulatory measures (FAO/WHO, 1997b).

- **Screened, screening:** (Process) Having separated various sized particles by passing over and/or through screens (AAFCO, 2000).

- **Shrimp Meal :** (Feed Ingredient) Shrimp meal is the undecomposed ground dried waste of shrimp and contains parts and/or whole shrimp. If it contains more than 3% salt (NaCl), the amount of salt must constitute a part of the brand name, provided that in no case must the salt content of this product exceed 7% (AAFCO, 2000).

- **Sifted:** (Process) Materials that have been passed through wire sieves to separate particles in different sizes. The separation of finer materials than would be done by screening (AAFCO, 2000).

- **Steamed, steaming:** (Process) Having treated ingredients with steam to alter physical and/or chemical properties (AAFCO, 2000).

- **Straight feedstuff or straights:** A vegetable or animal product in its natural state, fresh or preserved, and any product derived from the industrial processing thereof, and single organic or inorganic substance, whether or not it contains any additive, intended as such for feeding (HMSO, 1992).

- **Supplement:** A feed used with another to improve the nutritive balance or performance of the total and intended to be: (i) fed undiluted as a supplement to other feeds; or (ii) offered free choice with other parts of the ration separately available; or (iii) further diluted and mixed to produce a complete feed (AAFCO, 2000).

For additional feed terms and feed ingredient definitions see AAFCO (2000).

## 4. OVERVIEW OF AQUACULTURE FEED MANUFACTURING

- Although aquaculture dates back from the earliest parts of human history in Asia, Europe and in the Pacific Islands (Stickney, 2000), it is only in the last few decades that aquaculture has begun to catch up with the rest of animal agriculture in terms of the science of feed manufacture and nutrition.

- Aquaculture currently represents the fastest growing segment of agriculture and the animal feed manufacturing industry, particularly in mainland China and the Asian region where over 90% of global aquaculture production is currently realized (Akiyama & Hunter, 2000; Tacon and Forster, 2000).

- The manufacture of aquaculture feeds presents special challenges to the traditional feed milling concepts due to the aquatic medium in which the feed has to be delivered and ingested, and to the small size and variety of the animals being cultivated. For example, slow feeding animals like marine shrimp require the production of feeds which are physically stable in water for several hours. Moreover, farmed aquatic animals are

generally considerably smaller than their terrestrial counterparts, such as pigs, poultry and cattle; marine shrimp reaching a marketable size at only 20 grams.

It follows therefore, that the production of feeds for aquatic species requires a higher degree of precision be it the particle reduction of ingredients to sizes as low as 50 microns, or the precise mixing of as many as four dozen ingredients in a feed which is of minute size in comparison to its terrestrial counterpart (for general review see Akiyama and Tan, 1991; Barrows, 2000; Barrows & Hardy, 2000; Bartone, 1999; Dominy, 1994; Dominy et al., 1994; Erickson, 2000; Langdon, 2000a, 2000b; McEllhiney, 1994; Rokey, 2001; Tan & Dominy, 1997).

- These are the compelling reasons why many new feed mills are dedicated to aquatic feeds and often employ human food standards in production. Along with the higher standards of production come more expensive and higher quality standards for the ingredients used to prepare feeds for what are often very sensitive production animals (Boonyaratpalin & Chittiwan, 1999; Barrows & Hardy, 2000).

- The principles of the Hazard Analysis and Critical Control Point (HACCP) procedure may have application in aquaculture (FAO/NACA/WHO, 1999; Nickelson, 1998; Reilley & Kaferstein, 1997) and aquaculture feed milling (Hardy, 1991) if they are genuinely cost effective in terms of providing scientifically sound protection to animal and human health. Critical control points will have to be identified and in this regard FAO/WHO's Draft Code of Practice for Fish and Fishery Products (FAO/WHO, 2000a), which includes a special section (section 16) on aquaculture production, provides a model for possible adaptation.

- Good Manufacturing Practices (GMP) are represented in the balance of procedures outlined in these technical guidelines, and it is this use of GMP employed worldwide which has proven successful in production of wholesome and effective feeds (Whitehead, 1998). As a result, adverse health impacts on humans or animals from compound animal feeds has been negligible (FAO, 1998).

- While cleanliness of ingredients is important, ultimately the wholesomeness of feeds will depend upon the quality of ingredients (Jones, 2000) as well as the application of a treatment or process to eliminate disease producing organisms (i.e., Salmonella; Anon, 2001; FAO, 1998; D'Mello, 2001; Gill, 1999; Machin, 2001; Pearl, 2000; Said, 1996; Van De Venter, 2000) and to prevent possibility of recontamination after pelleting or extrusion is completed (Beumer and Van der Poel, 1997).

- It is on-farm management (husbandry) of cultured species which has the greater impact on product wholesomeness, including health of the animals and the human consumers. Pathogen destruction and reduction of toxicants involves a partnership at all levels of production from field to feed mill, to farm, to packer and processor, as well as care in preparation by the final consumer (FAO, 1998; FAO/NACA/WHO, 1999; Howgate, 1998; Spencer Garrett, dos Santos & Jahncke, 1997; Sutmoller, 1998).

- Research is needed to demonstrate management benefits of quality assurance (Q/A) programs and pathogen negative feed. Traditional microbiological tests for pathogens

are typically too slow to make HACCP practicable for aquafeeds (Cahill, 2000; FAO/WHO, 1995; FAO/WHO, 2000b).

- Indeed, while GMP may not meet the entire definition of HACCP, parts of GMP do meet some of the criteria for an overall HACCP programme, and it is important that aquafeed feed millers continue to use a programme which will minimize adverse animal and human health effects while continually improving feed production (Lobo, 2000). Contamination of feed after processing, by birds and rodents in particular, may be the single greatest hurdle to overcome (Fedorka-Cray and Lautner, 1996).

- Although much further research still remains to be undertaken so as to determine the precise dietary nutrient requirements of a wide variety of cultured aquatic species (Forster, 2000; Lovell, 1997; Shiau, 1998), as this information becomes available mill design and mill processing changes are inevitable. For that reason the aquatic feed miller of today must maintain flexibility within their mills and an awareness that changes are taking place as these guidelines are being written.

## 5. SITE LOCATION AND DESIGN OF THE MANUFACTURING FACILITIES

- The design and location of a feed mill should be guided by the customers it is to serve with important consideration given to soil conditions and whether or not an area is prone to flooding (Parr, 1988).

- It is important that the mill be located so that any impacts from wet conditions are minimized and the area kept free of heavy undergrowth and bushes.

- It is equally important that local transportation infrastructure be utilized to the extent that railroad spurs, wharves, and highways are considered for receipt of raw ingredients and also for the ease and cost-effectiveness with which the farmers are to receive their feed.

- Areas prone to flooding, tidal inundation, and fire should be avoided if at all possible. It is important to remember that if the mill cannot deliver feed on schedule due to flood or other natural disaster the feed miller is not the only one at risk, but it may put the farmer at risk as well.

- It is important to locate the plant such that future expansion of mill facilities can be accomplished cost-effectively. Initially, the mill equipment should be sized and designed to allow for expansion and easy change of equipment as new techniques in milling evolve and/or the culture species change. Flexibility in the mill design is vital if one is to remain competitive.

- Safety and hygiene factors should be built into the plant design. Buildings should be designed to prevent the entrance and harboring of vermin and birds.

- Cleaning and maintenance of all buildings and the avoidance of uncleanable recesses should be considered in the design and construction and in the selection of materials.

- The property should be configured to contain and/or manage any spills or runoff from the mill site. In wet areas elevator and receiving pits should have drains (and/or sump pumps) to prevent flooding (McEllhiney,1994).

- It is important, too, that the plant be a good commercial neighbor, that by design it is inoffensive and a positive force in the community, complying with local health, safety, and environmental regulations and always presents a clean and neat appearance.

- Regular inspections by management are important to assure the good outward appearance and a high standard of cleanliness, as well as to be certain that all equipment is performing to specification.

## 6. SELECTION AND PURCHASING OF RAW INGREDIENTS, INCLUDING INGREDIENT QUALITY CONTROL

- Quality feed begins with quality ingredients and it is the manufacturer's responsibility to make sure that the ingredients used within their feeds are wholesome and safe.

- To this end the manufacturer's buyer should have a set of standards for ingredients to be purchased and only purchase from reputable ingredient sellers who will comply with the mill's purchasing standards (Boonyaratpalin & Chittiwan, 1999; Pike & Hardy, 1997; Sitasit, 1995).

- Ideally the commodity merchants and supplement companies from which feed ingredients are purchased, should provide the buyer with specifications of exactly what is to be bought.

- It is inevitable that the quality of ingredients will vary, even from the same supplier from batch to batch and/or from month to month, and so it is important that this variability be characterised and monitored.

- To ensure the ingredients are meeting specifications, the nutritionist/quality control staff should conduct periodic sampling to verify the ingredient specifications are being met (Cruz, 1996; Dong & Hardy, 2000).

- In addition to the nutritional and analytical characteristics of the feeding stuffs, the specifications ought to include: origins and sources; any pre-processing details; hazards or limitations; miscellaneous information including moisture content and possible non-hazardous contaminants (stones, grit, etc.; Kangleon, 1994; Polidori & Renaud, 1995; Tan, 1993).

- All incoming ingredients should be inspected and tags/labels should be read for medications, trace minerals and other additives.

- In the event the analysis indicates that an ingredient does not meet mill specifications, and the supplier continually transports substandard ingredients, that supplier should be removed from the mill's supplier list.

- To become reinstated, a supplier must demonstrate that positive action has been taken to correct the deficiencies.

- All ingredient specifications should be reviewed annually or as needed to assure that utilisation in formulas is consistent with current, sound nutritional guidelines (the latest knowledge, in other words). The production manager is responsible for monitoring the specification list in co-operation with the purchasing manager.

- Grain or feedstuffs used in the manufacture of aquafeeds which are mouldy, treated/dyed or otherwise discoloured should not be used for any feed or food.

- Brightly coloured grain usually indicates seeds which are treated for use as rodenticides, or other pest control; these can be highly toxic to aquatic animals and man.

- Mycotoxins found in mouldy feedstuffs may, even at very low concentrations of a few parts per billion, have detrimental effects on farmed aquatic species (Li, Raverty & Robinson, 1994; Meronuck & Xie, 2000). There are over one hundred different mycotoxins and their impact on aquaculture species is still not well understood (Lovell, 2000; Trigo-Stocki, 1994).

- Similarly, low concentrations of pesticides or veterinary residues may have serious effects, not only on production of various aquaculture species, but accumulation of such residues may render aquatic species unmarketable if action levels in local regulations are exceeded (Boyd & Massaut, 1999; FAO/WHO, 1996; FAO/NACA/WHO, 1999; FAO/WHO, 2000c; GESAMP, 1997; Poh Sze, 2000; Spencer-Garrett, dos Santos & Jahncke, 1997).

- The aquaculture feed milling company and all its facilities should be in compliance with all government regulations (Boonyaratpalin and Chittiwan, 1999; Boyd, 1999). An example of compliance guidance is found in the Official Publication of the Association of American Feed Control Officials (AAFCO, 2000) by way of an inspection form for feed mills. This form may be utilised as a feed mill checklist or guideline as directed by the production manager.

- It would be wise for the aquafeed manufacturer to know their customer's receiving facilities well (Preston, 1995), to insure to the extent possible the correct care and use of feeds and ingredients.

- In some regions the farmers and feed stores may be required to comply with certain standards of storage and handling to assure freshness and minimal exposure to sources of contamination due to birds, rodents and other environmental factors.

- The supplier's warranty should be included in the purchase order showing suitability of an ingredient for feed use and that the ingredient is not adulterated and is in compliance with government regulations (UKASTA, 1998, 2000, 2001).

- All suppliers should furnish some type of official document which will permit the person in the mill responsible for receiving the product(s) to correctly and positively identify the inbound product and determine that the product actually belongs to the feed mill.

- Suppliers, or the transportation companies used to haul commodities, are responsible for ensuring the equipment is clean before they load it and that no material was hauled previously in the trucks, containers, barges or rail cars, which could be hazardous to animals. Conveyances should be certified clean and free of materials detrimental to aquatic animals and human health.

- Certificates of analyses of feedstuffs (where appropriate) should be requested periodically.

- When purchasing ingredients from a new supplier the following steps should be considered: perform on-site inspection of supplier's facilities, review standards of expectations (i.e., the raw materials should be clean and free from contamination), request supplier's certificates of analyses (where appropriate), request supplier's past laboratory data on ingredients to be purchased, request and review written quality assurance programs from supplier, verify supplier's reliability - check references for supplier reliability and availability of ingredients, request certificate of insurance or insurability on a routine basis from all suppliers and vendors, and request representative ingredient samples and analyse for appropriate items.

- Manufacturing quality control must insure that the feed produced will be consistently of a quality appropriate to the species fed. The process should include a comprehensive system of record keeping to document that the appropriate standards of a formula are being met throughout the period of manufacturing. Such records should be sufficient to make the product fully traceable (Cruz, 1996).

- The re-feeding of feed ingredients derived from non-processed and/or processed aquaculture products (including farmed fish and shellfish processing wastes, fish meal, shrimp meal, dead animals etc.) should be avoided at all costs so as to prevent the possibility for the spread of disease through feed (Gill, 2000a; UKASTA, 2001).

## 7. RECEIVING OF INGREDIENTS

- All incoming ingredients should be verified for correct labeling of product, purchasing specification, cargo destination, lot numbers/date, and regulatory compliance, as appropriate, especially for medicated feeds.

- Before acceptance and unloading procedures begin, the following factors should be considered: colour of the product, odour of the product, presence of any foreign

material, presence of any insect infestation, granulation (texture), density of the product, moisture, weight, and other appropriate factors (including temperature).

- A visual comparison should be made to a known sample of the ingredient. The contents of the carrier should be inspected for load depressions which could indicate leakage.

- Before or during unloading of all bagged ingredients (i.e., premixes, minerals, medications, etc.), a physical count should be taken and compared with delivery tickets and bills of lading. Any bag count variances or damaged products should be noted on receiving documents and on the bill of lading. The variances must be reported to the mill manager as well as the purchasing manager so that a claim can be made to the supplier and/or carrier.

- When sampling, utilize sampling procedures in accordance with section 13 of these guidelines concerning Sampling Methods and Analyses.

- Periodic random analysis for all ingredients should be made from time to time for nutrient values such as moisture, crude protein, crude fat, crude fibre, ash, calcium, phosphorus, salt, and other values, such as moisture, as appropriate. Microscopic examination may also be appropriate to determine quality of ingredients and premixes (AOAC, 1990; Bates, Akiyama & Lee, 1995; Jones, 2000; Khajarern & Khajarern, 1999).

- Before or during unloading, if any ingredient does not meet purchasing specifications, the production manager and/or purchasing manager should be notified at once, and he should have authority for "right of refusal."

- Refusal of a load can be a very difficult choice, especially if the mill is short of the particular ingredient which should be refused due to contamination, failure to meet specifications or any other valid reason. It is very risky to all customers and the financial stability of the mill if contaminated ingredients are allowed into the mill system. It may be very difficult and costly to remove the contamination, depending upon the nature of it.

- Documentation allowing a "paper trail" or chain of custody should be maintained which may include: type of ingredient received, date received, shipper, supplier, unloading assignment, number of bags, bag size, lot number, quality comments, and receiver's signature.

- Both bulk and bagged ingredients should be used in a manner such that first-in, first-out rotational procedures occur.

- All bins should be checked for bridging on a daily basis, depending upon the ingredient. When bridging or hang-ups are evident, debridging or dislodging efforts should commence as soon as practical. Great care needs to be taken here not to expose employees to asphyxiation and/or being buried alive with a sudden collapse of bridged material. The mass of grain or meal in a bridge situation can cause a tank to implode at the top when it breaks free with potential for serious injury to nearby employees (with an explosion-like effect at the bottom).

- Ingredients received by rail, barge, or truck should be checked for possible leakage conditions resulting from a physical defect in the vehicle. Rail car and sea container seals should be inspected to assure doors have not been opened or tampered with. Any broken seal or unsealed door should be noted and reported to the purchasing manager.

- When possible, all carriers of both bagged and bulk ingredients should be checked against shipper weights. Variances should be noted and reported to the purchasing manager.

- The bulk unloading area should be inspected daily for good housekeeping and safety practices. Complete clean up between ingredient changes should occur.

- Ingredient routings should be carefully made by the mill manager and double-checked by the mill superintendent before unloading the ingredients. Cross-contamination of ingredients can be a very costly mistake, putting crops, feed customers, and consumers at risk.

## 8. STORAGE AND HANDLING OF INGREDIENTS AND FINISHED GOODS

- Feed ingredients which are dry before processing should be kept dry and cool and used on a first-in, first-out basis. As a general rule the moisture percentage should be less than 13% particularly in humid and/or tropical areas (Cruz, 1996; Parr, 1988).

- The tanks in which these ingredients are commonly stored should be cleaned monthly, or as indicated by experience, to prevent the build-up of dust and fragments of feedstuffs. Such build-up creates habitat for mould (and therefore the possible production of mycotoxins) and insects which will quickly destroy the food value of the products being stored; heat is also produced by these organisms and spontaneous combustion resulting in serious ingredient losses, and possible property losses may occur. The elevator legs, other conveying equipment and spouting should also be routinely inspected and cleaned out for the same reasons.

- While processing may dilute or kill concentrations of mould and insects, keeping equipment and storage free of dust and build-up of old feedstuffs will prevent or at least reduce the possibility of contamination of the finished feed.

- Liquid ingredients such as tallow, amino acids, and molasses should be stored in accordance with manufacturers' recommended procedures to protect freshness.

- Fats and oils may need to be heated for ease of handling and/or have antioxidants added (to prevent lipid peroxidation and control off-flavors in food animals) to maintain quality (Hardy & Roley, 2000).

- In general, aquafeeds are usually composed of some highly perishable and often very expensive ingredients and care must be taken to keep both the feed ingredients and the

finished feed away from contamination including heat and light, as well as biological factors such as mildew, insects, birds and rodents (Cruz, 1996; O'Keefe, 2000).

- Propionic acid and other antifungal agents may be used during processing, but these chemicals may adversely affect palatability and efficacy of the feed. Both the feed miller and the farmer/end user of the feed need to remember that heat, light, and moisture can damage feed and that sacked feed should be stored off the ground on pallets, and out of direct sunlight due to the damaging effects of ultraviolet rays (New, Tacon and Csavas, 1995).

- Depending upon the source and nature of bulk feedstuffs, ingredient cleaning may be necessary. Most feed mills have grain cleaning systems, designed to remove broken seed, tramp metal, and other foreign materials which contaminate inbound ingredients from time to time.

- It is wise for the buyer to specify that dust (fines) and other contaminants shall not exceed a certain level. Inbound ingredients should be subject to rejection if contamination levels exceed specification.

- Aquatic animals are particularly sensitive to low levels of, for example, fumigants, and possibly mycotoxins, and for that reason great care must be taken in the choice, sourcing and handling of feed ingredients for aquaculture (Cruz, 1996).

- Bins, silos, warehouses, and ingredient handling systems should be designed so that moisture, rodents, birds and other pests are denied access. Regular cleaning of storage facilities will go a long way toward assuring a high quality finished product.

- One of the main components of receiving and storing is proper scheduling of the arrival of ingredients so as to minimize storage time and handling of the ingredients. Quality of ingredients, be they sacked supplements and/or medications, or bulk corn, or soybean meal, for example, may lose nutrient value or efficacy from excessive handling. Handling also invites problems with shrink.

- Misformulated, damaged or returned feed must be stored such that it cannot contaminate other feeding stuffs. Confirming analysis should be made to determine if such waste feed can be reprocessed, or must be destroyed. Here again a paper trail is important, especially for medicated feeds.

## 9. FEED INGREDIENT PROCESSING

- Processing refers to the individual or collective mechanical treatments applied to single or multiple feed components during the manufacture of compound aquatic feeds. These processes are carried out to modify the physical and nutritional properties of the ingredients and of the finished feed to ensure a consistent quality product. Key processes may include: batching, mixing, particle size reduction, conditioning, agglomeration, post pellet conditioning, fat coating, drying/cooling, crumbling and bagging.

- Magnets should be located above all processing equipment and be checked and cleaned as required by the production superintendent. Failure to capture tramp iron may result in expensive repairs to equipment, injury to personnel, contamination of product, delivery delays, or all of these problems at once, including customer dissatisfaction.

- Production runs of medicated feeds manufactured on processing equipment should be grouped together as much as possible. When sequencing is not possible, the processing system should be flushed with ground corn meal, or similar ingredient. Flush material should be routed into the same medicated batch, whenever possible.

- All equipment operators should be familiar with basic equipment operation, such as that contained in the particle size reduction operator's manual, pellet mill operator's manual, extrusion operator's manual or other mill equipment manuals.

- Before starting the equipment, the operator should check the flow of the product to its destination to prevent cross-contamination. Particle size reducing machinery (hammer mills, roller mills, etc.) should be routinely checked for correct particle size.

- When pelleting, product should be checked for pellet durability and pellet water stability where appropriate (Tacon & Obaldo, 2001).

- Proper conditioning with steam will enhance the process of starch gelatinisation, which in addition to enhancing digestibility also improves pellet stability in water (Bartone, 1999).

- For extrusion of the formula, the product should be checked for shape, bulk density, floating, slow sinking, or sinking, and also routinely checked for correct particle size (McEllhiney, 1994).

- Turnheads, distributors, diverter valves and spouting should be routinely checked for operability, leaks and accuracy. The miller must know that the ingredients are reaching the processing destination intended.

## 10. FEED FORMULATION AND MANUFACTURING

- Aquafeeds should be manufactured according to a formula recommended by a competent nutritionist and should be specific for the aquatic target species being fed and intended farm production system (Csengeri & Tacon, 2000; Tacon, 1996).

- While most temperate freshwater diets may be largely based upon the use of plant protein and energy sources, and cold water marine diets are largely based upon the use of fishmeal and other fishery by-products, there can be regional differences which reflect optimal use of locally available and/or least-cost formulation of ingredients (Lazo & Davis, 2000; Li, Robinson & Hardy, 2000).

- In most existing feed mills the coarse grains and possibly other ingredients will be ground in a hammer mill, roller mill or otherwise prepared by appropriate means to allow uniform mixing of the ingredients to formula specifications and further processing by pellet mill or extrusion to the cooled and finished product. The feed, properly cooled and dried after processing, is then ready for sacking or bulk delivery to the farm.

- The particle size(s) of the ingredients may be limited by the type of process equipment available in an old mill. In aquaculture feeds particle sizes are typically smaller, some as small as 50 microns to allow proper mixing, pelleting or extrusion of the feed (Erickson, 2000; Halvorsen, 2000).

- An important factor is the conditioning and cooking process of the mash, whether it is to be pelleted or extruded (or a system which employs the principles of both), the starch must gelatinize so that the feed is digestible and maintains its integrity in water. This will assure that the feed nutrients are consumed by the animal and do not end up as fertilizer or potential pollutant within the intended farm production system (Bartone, 1999).

- Generally, pelleting is less expensive than extrusion and may be cost-effective depending upon a variety of factors including the type and behavior of the species being cultured, types of ingredients available, and resources of the feed miller.

- Newer hybrid machines which combine the best attributes of both pellet mills and extruders may be an exciting development for aquaculture. For specific details on the different types of manufacturing processes which may be employed for the production of animal feeds, including aquaculture feeds, readers should consult Akiyama and Tan (1991), Barber (2000), Barrows (2000), Barrows & Hardy (2000), Best (1999), Gill (2000b), Kearns (1998), McEllhiney (1994), Pipa & Frank (1989), Riaz (2001), Rout & Bandyopadhyay (1999), Sunderland (2001), Tan & Dominy (1997), Tsang (2001) and Woodroofe (1999).

**For aquafeeds prepared from manufacturer's formulas:**

- Formulations should be determined by the manufacturer's resident nutritionist, based upon the known dietary nutrient requirements of the animal and farming system for which the feed is being formulated, prior practice, or research findings.

- The mill should use reasonable and accurate nutrient specifications for each ingredient.

- Since the dietary nutrient requirements of farmed aquatic species are still being defined, it is important for the feed miller/nutritionist to stay abreast of current research knowledge and findings.

- Use of drugs and other ingredients should follow ingredient label directions and regulatory requirements. (The supplier's label should be followed. Do not use a product for which there is no label; consult management for guidance.)

- All medicinal feed additions (drugs) should be stored separately from all other feed materials, products and premixes. Access to the drug storage area should be limited to authorized personnel only (UKASTA, 1998, 2000).

- The production manager should be responsible for the plant having a complete set of current formulas for the aquatic species to be fed.

- All formulas must indicate: the formula identification (number), feed name (type and species), effective date, weight/percent each ingredient, and drug/medication (if used).

- Obsolete formulas should be filed at the feed mill for at least one year after last use.

**For aquafeeds prepared by the customer's formulas (custom feeds):**

- Before a customer formula feed can be manufactured, there should be approval from the general manager. Custom formulas are those orders which deviate from a standard production formula and are specifically requested by a customer.

- The basis for approving a custom order may be as follows: that there is no alternate feed in the program that will do the job, that the plant is physically capable of producing the feed and the feed ingredients will not compromise the quality of other feeds manufactured in this mill, and that it must be legal (check with a government feed control official).

- Each and every customer request should be reviewed for approval. Blanket approvals should not be allowed.

- Typically, a consent is obtained from the customer that will essentially release the manufacturer from liability for impaired animal performance.

- Mixing and batching aquaculture formulations: the batch operator should receive proper training for the task of mixing and should have an understanding and working

knowledge of ingredients, premix, drug, and concentrate labelling, equipment function, ingredient and product flow, weights and measures, and equipment maintenance.

- Maintenance of production records: production records should include the following information: date mixed, type of feed mixed, formula and lot number, actual yield, mixing personnel, bin assignment, drug inclusions, and sequencing and flushing.

- Production runs of medicated feeds should be grouped together as much as possible. When sequencing (grouping) is not possible, flush the mill mixing system with an adequate amount of ground corn meal, or similar major ingredient. Flush material should be routed back into the same batches of similar medications.

- All liquid application systems should be check-weighed quarterly for accuracy by the production manager or representative. Mixing times for all feeds should be posted.

- Batch scales should be check-weighed for accuracy on a regular basis and inspected annually by an authorised scale inspection company (or qualified government entity).

## 11. PACKAGING AND LABELLING

- The function of packaging is to protect the finished feed from light and moisture and other environmental contaminants. Together with labelling, it should tell the farmer the identity of the manufacturer and the type of feed it is.

- The feed label describes the contents of the sack or package and the species for which it is intended. For bulk feed, that which may be delivered in quantity as by truck, or sea container, the label and instructions for application of the feed should be attached to the invoice.

- If the feed is medicated, warnings should be clearly evident along with specific instructions for the species being fed.

- Details of what must be accomplished for packaging and labelling of finished feed should include:

**Bagging:**

- The sack-off operator should check and clean all equipment before bagging;
- Scales should be tested for accuracy, including bag tare;
- Verify bags and/or tags are properly coded for the day's run;
- At the beginning of a bagging run, initial bags of a new feed may need to be set aside until proper consistency of product quality is observed. The feed in these bag(s) may be remanufactured and does not necessarily have to be thrown away. If the feeds are

medicated the mill superintendent should be consulted before re-running the feed; all bags should be properly labelled, including instructions for feeding the species to be fed; and

- At the beginning and throughout every run, bags should be periodically check-weighed; and all scales must be certified annually.

**Labels and Tags:**

- Labels and feed tags will conform to the law published by the jurisdiction in which the aquaculture feed products are being sold.

**It should be the responsibility of the feed mill manager to:**

- Co-ordinate the layout and printing of tags;
- Check the tags for accuracy and government compliance before tags are printed in quantity;
- Labels should be received, handled and stored in a manner that prevents mislabelling and assures the correct label is placed on the correct feed;
- All deliveries of feeds, whether bagged or in bulk, shall be adequately labelled and contain appropriate instructions to assure the feed can be properly fed to the aquatic species intended; and
- Only tags for the product being bagged should be in the bagging area. Remaining or excess coded (dated) tags should be destroyed immediately. For bulk feeds (as in large tonnages delivered by truck) the label and feeding instructions should be attached to the invoice or delivery documents.

## 12. WAREHOUSING AND SHIPPING

- Up to this point in feed production great care has been taken in the manufacturing and materials handling of aquafeeds. Similar care must be taken in the warehousing and shipment of the final product.
- Sacked feeds must be stored in the warehouse off the ground on pallets away from sunlight with approximately one third of a meter between pallets to assure good air circulation.
- Storage should always be on a first-in, first-out basis.
- Storage of finished feeds must be carried out with the protection of the target species and human health as primary considerations. By meeting these objectives the feed miller should insure customer satisfaction.

- Shipping and distribution records should be maintained to facilitate recall of specific production batches/runs to the mill if and when an error occurs in processing. (See Appendix I, Outline of Procedure for a Product Recall.)

- Bulk feed shipping documents should identify contents of each compartment in a truck or shipping container.

- All bagged products which are shipped should be in good condition (no ripped or otherwise leaking bags). All products sold and shipped should be properly weighed, and a copy of the shipping/billing order should accompany them.

- Bulk feed delivery trucks carrying medicated feeds should be appropriately flushed or sequenced, to assure that subsequent deliveries are not contaminated with unauthorised or detrimental chemicals, which could adversely affect other customers.

## 13. SAMPLING METHODS AND ANALYSES

- Sampling of raw ingredients and the finished products of aquaculture feed milling should be conducted routinely so as to be certain that the raw materials going into the feed and the finished feed itself meet formula specifications (Bates, Akiyama and Lee, 1995) and do not contain any defects which could be harmful to the farmer's crop or the human consumer. For additional information and details see AFIA (1993), AOAC (1990), Boonyaratpalin & Chittiwan (1999), Divakaran (1999), Dong & Hardy (2000), Hardy & Roley (2000), McEllhiney (1994) and Parr (1988).

**Ingredients:**

- If bulk truck shipments are sampled, samples should be taken from the beginning, middle and end of the discharge stream. Avoid taking samples from the very beginning and very end. Grain should be sampled with a grain probe in at least 5 locations (4 corners and middle).

- Railroad box cars, barges and sea containers may be sampled in several locations during the unloading operation. Avoid taking samples close to the outside walls.

- If sampling railroad hopper cars (and some barges), each compartment should be sampled by obtaining 3 samples at appropriate intervals (beginning, middle and end of loading) during the discharge. Avoid sampling the very beginning or very end of the discharge.

- Samples of liquid ingredients (i.e., fats, oils, tankage) may be taken from the unloading stream after the load has been allowed to discharge for at least 5 minutes.

- If sampling bagged shipments, samples should be taken by diagonal probing. (The hole made by the probe should be resealed with tape immediately after sampling.)

- All subsamples should be placed in a large container, mixed, and approximately 1/4 to 1/2 kilogram placed in an appropriate container. All samples should be identified by date, car

(barge, container, etc.) number, ingredient, receiving report number, supplier, sample name, and name of sampler.

- Ingredients should be periodically tested when or if pesticides or other toxicants are suspected, and, in some instances, the product should be checked microscopically. Sampling to determine whether ingredients meet specifications may be necessary if there is any doubt about the quality of goods received.
- The production manager should determine what tests are appropriate and should be responsible for evaluating the results.
- All samples of ingredients and finished product must be well-preserved and protected against destruction (rodents, insects, etc.), deterioration (moisture, mould, etc.) or adulteration. A preferred means of preservation is to put the samples in a chest freezer or refrigerator.

**Finished Feeds:**

- Every production run, bag feed or bulk, should be physically inspected for: colour, odour, texture, and moisture (when appropriate).
- Samples of bagged production runs should be taken periodically.
- When sampling bulk shipments, appropriately spaced samples should be taken at intervals (beginning, middle, and end of loading). Taking samples at the very beginning or end of the loading process should be avoided.
- All subsamples should be placed in a large container, mixed, and approximately 1/4 to 1/2 kilogram placed in an appropriate container. Bagged production run samples should be identified with a properly coded tag. Bulk or liquid feed samples should be identified by customer name, date delivered, and quantity (kilos, etc.).
- The production manager should determine appropriate tests and be responsible for evaluating the results.
- The above sampling procedure may also apply to liquid feeds, premixes, supplements, and concentrates. Analytical testing of specific ingredients for toxicants should follow standard AOAC (1990) methods or equivalent nationally approved analytical methods.

## 14. RECALLING DEFECTIVE OR MISLABELLED PRODUCT

- Most feed manufacturers use a broad range of ingredients, and there is a chance that a product recall could be necessary if there were sufficient evidence of a feed quality or labeling error.
- Not only may there be a potential violation of government regulations and a danger to aquatic animals and/or consumers, but the continuing healthy relationship with the farmer must be maintained.
- To this end an efficient and successful product recall procedure involving products manufactured by the mill is necessary and should reduce or save a serious liability

claim against the manufacturer and maintain a helpful relationship of trust with the customer.

- All product recalls have customer and public relations implications that make it absolutely necessary that a recall be handled quickly and properly and that it be well documented so that future legal defence, if required, may be based on the company having taken proper and timely action to minimise any threat to the farmer's production or any government intervention.
- Government agencies may be involved in a product recall, and a procedure for dealing with such an eventuality is detailed in Appendix I.

## 15. PLANT CLEANLINESS AND WORKER SAFETY; HOUSEKEEPING

**General:**

- The feed milling company should be committed to maintaining a quality housekeeping programme that provides a safe and healthy environment for its employees and the community.
- The intent is to maintain mill properties in a manner that minimizes loss to persons or property and maximizes product quality assurance.
- Housekeeping is a direct responsibility of all employees, and each should be held accountable to do the things necessary to implement an effective housekeeping programme.

**Practices:**

- Trash should be disposed of or recycled as appropriate.
- Feed and/or ingredient spills should be cleaned up immediately. Spilled materials should be put in designated, marked containers for proper disposal.
- Fugitive dust points should be investigated, evaluated, and corrective action taken.
- Offices, break rooms, and restrooms should be cleaned regularly.
- All employees should keep their work areas clean and orderly.
- All areas of the plant should be cleaned daily.
- Hand tools should be picked up and stored.
- Pallets of bagged products should be stacked neatly and in an orderly way. Broken bags should be taped and reclaimed as soon as possible.

**Pest Control:**

- All broken windows should be repaired and the building kept tight to deny access to the mill from birds, rodents or other factors which may adversely affect the quality of the finished feed.
- Insects and rodents. The plant and warehouse should be baited and fogged as needed using approved pest control methods. Baits and fumigation should be done by trained personnel, preferably an approved, licensed pest control agency. A record should be kept of all pesticides used and the type of applications.

## 16. PLANT MAINTENANCE AND REPAIR

The plant maintenance program is vital to consistent production of high quality feeds and no less important to cost control and assurance to the customer that their feed will arrive on time and to formula specification (Parr, 1988).

Equipment breakdowns are bad enough as they impede aquaculture feed production, but at least as bad is machinery which is not working to design which may, through short weighing, or improper mixing, produce a defective feed.

Such defective feed may, at the least, hurt the farmer's production and at worst create a serious crop failure. Also possible is a threat to human health.

Keeping motors, scales, pellet dies, conveyors and all other components of the mill in proper working order is as important as formulation or the quality of ingredients which go into the finished feed.

Mechanical or electronic failures may occur from time to time in a complex system like a feed mill, but proper attention to preventive maintenance will minimize down time and the prospect of the customer receiving feed which is out of specification. The latter may cause a costly recall of feed or possibly compensation for damages to the customer's crop, if the error is not found in a timely way (Appendix II).

A good preventive maintenance programme should provide adequate maintenance at reasonable cost (Appendix III).

**Preventive Maintenance Objectives:**

- Reduce major repairs by correcting minor difficulties as soon as they are evident. This means listening to your operators who usually recognise before management that machinery is making a "funny noise" or other irregularity in performance of equipment. Do not punish employees who are trying to report a defect beyond their control.
- Maintain equipment in a more productive state. Keep it clean; repair or replace lost or worn parts immediately. Follow the machinery manual recommendations.

- Improve scheduling of repairs. Do not postpone needed repairs. Delaying repairs usually results in much more costly problems later on.
- Maintain safety. Some parts as they become worn become dangerous, as in worn chain or belt drives. Staff are valuable and injuries are costly from the standpoint of lost time and training replacements, not to mention adverse impacts on employee morale.
- Improved customer service. A well-maintained mill looks good to the customer and helps assure the customer that the feed is made correctly the first time.
- Reduce overall operating costs. The miller of aquaculture feeds benefits from a well-maintained facility through reduced costs of operation and customer satisfaction.
- Provide trained maintenance personnel. Training of maintenance staff should be a high priority with high-level management oversight. Too often maintenance is seen as the bottom of the ladder, when in reality the quality and training of staff for this important responsibility should be paramount.

**Building and Grounds Maintenance:**

- The building grounds shall be adequately drained and maintained to be reasonably free from litter, waste, refuse, uncut weeds or grass, standing water and improperly stored equipment.
- The buildings shall be maintained in a reasonably clean and orderly manner.
- Adequate space, ventilation and lighting shall be maintained for the proper performance of all manufacturing, storing, labelling, quality assurance and maintenance aspects of aquaculture feed manufacturing.

**Preventive Maintenance Areas:**

- In Appendix IV a checklist is provided to highlight generalised preventive maintenance functions, which are to be checked periodically. Each plant manager should take this guideline and revise it to conform to the actual conditions of his plant.
- A log (record) book or computer record should be maintained on a daily basis. Careful attention should be paid to the equipment manufacturer's suggested maintenance schedule(s).

## 17. PERSONNEL

- Quality aquafeeds can only be made by knowledgeable and trained personnel.
- Training is an on-going process mentioned in various sections above, and can be summarized as follows: General management should have formal training in feed technology, sufficient to assure the competent purchase and handling of quality ingredients, correct manufacture, storage and handling of finished feeds. In addition to assuring that the feed manufactured meets the intended specifications for the species to

be fed, the manager must maintain documentation of the process sufficient to allow accurate tracing of the ingredient sourcing and manufacturing events of a finished feed. This will include a record of who received the feed, and any other pertinent details including medications.

- Personnel should receive refresher training on a regular basis, or additional training on new equipment and/or processes to be employed. There will be a particular emphasis on regular safety meetings where employees will make known any safety problems (violations) in need of correction. A log or journal of safety meetings should be kept. Particular attention must be given to record keeping as it relates to animal health products; these should always be stored separately from other ingredients to avoid any possibility of cross contamination.

- Procedures for training and refresher training, as well as plant organizational structure shall be sufficiently flexible as to allow immediate adaptations to changes in evolving aquafeed technology. Certification of management and staff may become essential for ingredient purchasing, process control, and quality assurance.

- Every employee from top management on down should have a working knowledge of the mill and the various specialities required to produce a finished product. Cross training can be a particularly valuable means of problem solving and lead to greater flexibility in a feed mill.

- Regular meetings to express customer satisfaction, evaluate procedures, introduce new technology, and problem solving, will assure effective communications up and down the chain of command (UKASTA, 1998, 2000).

## 18. DOCUMENTATION

- Documentation is a prime necessity in quality assurance and traceability.

- Its main purpose is to define the system of control required to reduce the risk of error. This must include defining and mastering the critical points in the manufacturing process and establishing and implementing the quality control plan.

- It is also designed to ensure that personnel are instructed in the details of the necessary procedures and to permit investigation and tracing of defective products.

- The system of documentation should be such that the history of each batch, blend, or run of product may be determined.

- Documentation must be both adequate and systematic and relate both to the manufacturing process and to quality assurance.

- All relevant documents including those referring to quality assurance or HACCP procedures, must be retained for an appropriate amount of time, or as required by local regulations.

- An example of an existing Code of Practice and good procedure to follow is outlined in the UKASTA "Code of Practice for the Manufacture of Safe Compound Animal Feedingstuffs" (UKASTA, 1998, 2000) and the Draft Code of Practice for Good Animal Feeding (FAO, 1998; Appendix IV).

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## APPENDIX I: OUTLINE OF PROCEDURE FOR A PRODUCT RECALL

### 1. Summary - Product Recall

Potential product recalls should be quickly reported and investigated by a responsible decision-maker who has the authority to assign the recall classification to the situation. When warranted, a Recall Committee should be appointed.

The Recall Committee and its chairman should be quickly convened when a Class I, II, or III situation exists.

All information received and communication released regarding the recall should be approved by the chairman of the Recall Committee.

Complete records and samples should be kept in the control of the production manager. Communication is so critical in a recall situation that the members of the Recall Committee may need to devote nearly full time to the emergency in its earliest stages. A telephone hotline may need to be installed for customer and other inquiries.

The recall policy and procedures should be reviewed each year.

### 2. Definitions

The following are possible government definitions for the product recall procedure.

Class I Recall - A serious emergency recall situation involving product which may have an immediate or long range effect on the life or health of aquatic animals or human consumers.

Class II Recall - A priority situation involving product which may be a potential hazard to human or animal life or health.

Class III Recall - A situation involving product which does not pose a health threat, but which may have serious or wide-spread customer or public relations implications.

External Recall - The removal of product from the market in which distribution has been made beyond the direct control of the feed miller's organisation.

Internal Recall - The removal of product from the market, none of which has left the direct control of the manufacturer.

Retention - Holding product from the market or from further processing or shipment when there is evidence of a quality or labelling deviation in the formula for the target species.

## 3. Procedures

When the potential for a recall becomes evident, the production manager and quality control manager should be informed immediately.

The quality assurance manager may assume the responsibility to immediately investigate, using any resource within the company, to determine whether the situation is a Class I, II, or III recall or is of lesser priority. The quality assurance manger needs to make the classification decision as quickly as possible.

If the decision is that it is a Class I, II, or III recall, the quality control manager should immediately convene the Recall Committee. The chairman should then co-ordinate all recall activities, keeping the committee members informed. A lesser priority situation may be handled at the plant level without a committee being convened.

The Recall Committee should include persons with expertise in these areas:

- Regulatory
- Production
- Sales
- Quality Control
- Public Relations
- Legal
- Purchasing
- Nutrition

The Recall Committee should decide the quickest and best overall procedure for handling the recall. Since each situation will be unique, the following are guidelines which may be useful:

- Determine the suspected product's identification codes and the dates of its manufacture.

- Determine where the entire product is now located. In other words what is the status of the aquaculture feed in question?

- Immediately notify all locations where the product was shipped. Mandate a "stop sale." If the product has been sold to consumers, contact the sellers (distribution) and ask them to make a listing of all consumers who received the product.

- Get the Recall Committee input as to how to handle all contacts outside the company, such as consumers, agents, dealers, media, etc.

- Decide whether the media need to be notified. If so, let the public relations department or its designee handle it.

- Decide whether government agencies should be immediately notified. They may be of help, but may also make matters worse if the officials believe a concealment has been attempted.

- Someone should be assigned to make and retain accurate records of what was produced, shipped and later accounted for, and finally disposed. Also a record of recall actions and their date and time may be needed for legal protection.

- Be sure any samples secured are properly identified and safeguarded; refrigerate if appropriate to prevent degradation . If sample analysis is required, have it done on an expedited basis while always retaining duplicate lots of each sample lot submitted.

- Communicate. Keep the Recall Committee, the plant manager, any customers, and the news media (if necessary) informed, so that inaccurate information cannot accidentally replace facts or is misconstrued.

- A 24-hour hotline phone number may need to be implemented, to answer any questions from consumers.

4. **Recall Committee** Name Home Phone

Chairman: _____ _____

Public Relations: _____ _____

Production: _____ _____

Sales (Retail): _____ _____

Quality Control: _____ _____

Purchasing: _____ _____

Legal: _____ _____

Regulatory: _____ _____

Nutrition: _____ _____

Additional Contacts in a Product Recall

Insurance Carrier: _____ phone #

Hotline: Government Agriculture Department

Government agencies should only be contacted by the Chairman of the Recall Committee. When reporting a recall to a government agency, be sure to record the date and time of the call and the name of the government employee taking the call.

5. **Optional Recall Check List**

| | | Yes | No | Comment |
|---|---|---|---|---|
| 1. | Has the Recall Committee been activated? | ___ | ___ | _____ |
| 2. | Has the suspect product been identified? | ___ | ___ | _____ |
| 3. | Has the identification code and date been determined? | ___ | ___ | _____ |
| 4. | Has it been determined where all the product is located at present? | ___ | ___ | _____ |
| 5. | Have all affected locations been notified? | ___ | ___ | _____ |
| 6. | Has product been shipped to consumers? If so, has a consumer list been established? | ___ | ___ | _____ |
| 7. | Have consumers been notified? | ___ | ___ | _____ |
| 8. | If appropriate, have the media been contacted? | ___ | ___ | _____ |
| 9. | Has a government agency been notified? If no, why? | ___ | ___ | _____ |
| 10. | Have the following documents been secured? | | | |
| | • Batching records surrounding product | ___ | ___ | _____ |
| | • Shipping records | ___ | ___ | _____ |
| | • Ingredients records | ___ | ___ | _____ |
| | • Bulk records | ___ | ___ | _____ |
| | • Bagging records | ___ | ___ | _____ |
| | • Labelling records | ___ | ___ | _____ |
| | • Minutes of Recall Committee | ___ | ___ | _____ |
| 11. | Have samples been received and properly identified and preserved? | ___ | ___ | _____ |
| 12. | Are samples safeguarded? | ___ | ___ | _____ |
| 13. | Have samples been analysed for the suspected source and/or cause of incident? | ___ | ___ | _____ |

In notifying a customer, consumer or a dealer/distributor remember to:

- Alert, but do not alarm
- Be frank and honest
- Advise of lot (ID) numbers in question
- Have a workable feed replacement program
- Be prepared to answer questions or complaints
- Document in detail all conversations

## APPENDIX II: PRODUCT AND PERFORMANCE INVESTIGATIONS AND CHECKLIST

### 1. General Considerations

Throughout this section, the terms complaint, claim occurrences, demands and suits are used interchangeably, meaning that a third party, usually a customer, is dissatisfied with a product or service, resulting in an alleged setback to his/her financial worth. These terms could also refer to bodily or personal injury suffered by an individual because of some alleged negligent act of the company. Customer complaints as well as general liability claims may occur from time to time. The successful handling of these complaints/claims may be dependent upon prompt, factual and inclusive information relative to the claim/complaint.

Prompt attention to a customer's or complainant's problem can usually prevent the problem from becoming serious. The manufacturer should stand behind its products. If in error, its policy should be to promptly settle the obligation created by its error. Complaints that are ignored or not properly handled may end up in litigation, which is costly. If there is an error in the formulation, the mill should pay the claim or will pay to prove the mill was not at fault. No complaint is too small. Denial of even the smallest complaint could cost the company unnecessary time, money, and aggravation. Every complaint should be handled so that the manufacturer is in a defensible position should litigation occur.

### 2. Product and Performance Investigation Files

Detailed, well documented files are crucial to claims defence and settlement. The quality assurance manager should be responsible for maintaining accurate and current information on the following files:

- Non-medicated investigation files.
- Medicated investigation files.
- Customer service reports.

The production manager should review the product investigation file weekly, to make sure claims are settled or satisfied.

### 3. Suggested Do's and Don'ts in Handling Feed Investigations

Feed complaints should be handled quickly and completely. Two weeks may be too long. Advance planning for a specific course of action to take is a must. Outlined below are several ideas about the right and wrong way to handle product and performance investigations.

- Do take all complaints seriously from the very instant they are presented. Little complaints can develop into big complaints and into excessive legal claims in lawsuits.

- Do analyse the over-all situation thoroughly while the facts are fresh. Utilise a standard check-off list in order to cover all possible questions.

- Do call a knowledgeable veterinary or other aquaculture consultant for a third opinion as required, based on the nature of the claim.

- Do take a proper representative sample of the feed product in question. Sampling of the feed should be done according to the prescribed standards of the industry in an aseptic (sterile) manner. Sometimes it is possible to arrange for the feed control official to take the representative sample. Similarly, water samples should be taken at the farm as close to the time of the event as possible.

- Make sure to take pictures (colour slides preferably) of animals, feed facilities, losses and the farm/mill/pond/raceway at the time of the complaint. If sick and/or dead animals are involved, the on-site investigation should be done as soon as possible with the customer in attendance and a qualified aquaculture veterinarian representing the feed mill.

- Be extremely careful in handling and mailing samples. The use of registered mail is essential. The use of accredited laboratories is also essential.

- If the judgement is to stop feeding the product, pick up all questionable feed products immediately. Supply a new batch of fresh feed after completely analysing the formula, the quality control procedures and insuring that any feed tank is thoroughly cleaned out. Remember, picking up the feed is no admission of guilt, but is a good precautionary practice.

- Obtain prompt veterinary diagnosis. This may be confirmed with a second consulting veterinarian not associated with the customer. Remember that a qualified veterinarian should be involved at the beginning. It is well to have a veterinarian on retainer, anyway, to handle customer questions and to work with the nutritionist.

- Keep accurate records on the name, address and phone number of all parties involved.

- Keep an accurate chronology of all events; dates, times, weather, water conditions, etc.

- Obtain the exact description of the complaint. Document it with numbers, facts, and photographs as appropriate.

- Check the water source(s) for contaminants. Chemical and/or microbiological tests may be advisable.

- Do not procrastinate to settle a claim directly with the customer. If it is a salesman's error in taking the order, a mistake by the truck driver in delivering to the wrong bin, a mistake at the plant in using the wrong formula, etc., report it to management immediately, and make the appropriate amendments promptly. This quick action may save a great deal of time, effort, and money, and above all, will retain the confidence and good will of the customer.

- Do not take "opportunist's claims" lightly. Report them to management immediately. This may be a clue the individual is looking for a way out of paying an overdue feed bill.

The information contained in the Product and Performance Investigation Checklist below should be obtained.

**AQUACULTURE PRODUCT AND PERFORMANCE INVESTIGATION CHECKLIST**

Date of Complaint: _____ Customer's Name: _____
Address: _____
Phone No.:_____ Value of Complaint: _____

Description of Complaint:

| | | Yes | No | Comment |
|---|---|---|---|---|
| 1. | Responded to complaint in 24 hours? | ___ | ___ | _____ |
| 2. | Was a complaint investigation conducted? | ___ | ___ | _____ |
| 3. | Was a field investigation conducted? | ___ | ___ | _____ |
| | If so, | | | |
| | • Were product samples taken from feeder, tanks? | ___ | ___ | _____ |
| | • Were water samples taken? | ___ | ___ | _____ |
| | • Were other ingredient samples taken? | ___ | ___ | _____ |
| | • Were pictures, movies or video taken? | ___ | ___ | _____ |
| | • Were pond/raceway conditions reported? | ___ | ___ | _____ |
| | • Were statements from employees taken? The delivery driver is especially important | ___ | ___ | _____ |
| | • Were lot numbers verified? | ___ | ___ | _____ |
| 4. | Was a product recall considered? | ___ | ___ | _____ |
| 5. | Were there sick or dead animals? | ___ | ___ | _____ |
| | If so, | | | |
| | • Veterinarian report obtained? | ___ | ___ | _____ |
| | • Veterinarian authorisation forms obtained? | ___ | ___ | _____ |
| 6. | Completed production and delivery investigation report? | ___ | ___ | _____ |
| 7. | Lab report for complaint sample(s) & water sample received? | ___ | ___ | _____ |
| 8. | Called a product recall committee meeting? | ___ | ___ | _____ |
| 9. | Contacted insurance company? | ___ | ___ | _____ |
| 10. | If medicated feed, contacted drug company? | ___ | ___ | _____ |

| | | Yes | No | Comment |
|---|---|---|---|---|
| 11. | Offer settlement? | ___ | ___ | _____ |
| | If so, | | | |
| | • Was it successful? | ___ | ___ | _____ |
| | • Was a release signed? | ___ | ___ | _____ |
| | • Is there evidence of a suit? | ___ | ___ | _____ |
| 12. | Were there witnesses, if so who? | ___ | ___ | _____ |
| 13. | Was a list made of other users of product? | ___ | ___ | _____ |
| 14. | Was feed picked up? | ___ | ___ | _____ |
| 15. | Were lot samples sent for analysis? | ___ | ___ | _____ |

Person completing check list:

Attach copies of all reports and documents to this sheet.

## APPENDIX III: PREVENTIVE MAINTENANCE IN THE FEED MILL

| EQUIPMENT | MAINTENANCE FUNCTIONS TO BE CHECKED |
|---|---|
| BUCKET ELEVATORS | Cups, belt, splice drive<br>Gear box<br>Grease bearings<br>Tension & alignment |
| FEED MIXER | Gear box<br>Gates & oiler<br>Grease bearings<br>Check drive<br>Ribbons or paddles<br>Air sweep<br>Traps |
| CHAIN DRAG CONVEYORS | Paddles<br>Chain condition & sprockets<br>Gear box<br>Drive<br>Grease bearings<br>Vari-speed unit (bearings, belt)<br>Trough |
| SCREW CONVEYORS | Flighting<br>Gear box<br>Drive<br>Grease bearings<br>Vari-speed unit (bearings, belt) |
| PELLET MILL | Oil<br>Change oil & filter<br>Vari-speed unit<br>Grease rolls<br>Grease bearings<br>Main bearings & drive<br>Grease motor bearings<br>Check rolls & die condition |
| COOLERS | Chains<br>Vari-speed unit<br>Mesh<br>Grease bearings<br>Gear box<br>Drive |

| | |
|---|---|
| CRUMBLER | Belts & drive<br>Grease bearings |
| SHAKER & SCALPERS | Screens<br>Gear box<br>Grease pads<br>Grease bearings |
| GRAIN DRYERS | Chain<br>Drags<br>Elevators<br>Bearings |
| DUSTING REEL | Drive & bearings |
| BLENDER | Vari-speed unit<br>Grease bearings<br>Drive & belts |
| HAMMER MILL | Screens & hammers<br>Clean magnet<br>Grease bearings<br>Drive & gear box<br>Clutch<br>Housing |
| ROLLER MILLS | Magnets<br>Belts<br>Rollers<br>Bearings & locks<br>Tighteners |
| BAGGER | Gear box<br>Gear bearings<br>Air oiler<br>Gates & air cylinders |
| SEWING MACHINE | Oil & clean |
| BAG CONVEYORS | Drive & belt<br>Grease bearings |
| AIR COMPRESSORS | Check oil<br>Drain water<br>Belts<br>Filter<br>Change oil |

| | |
|---|---|
| RAILROAD CAR PULLER | Check oil<br>Gear condition |
| BOILER | Sample water & add chemical as required<br>Pressure safety valves<br>Low water cut-off<br>International inspection<br>Burner function<br>Pump lubrication<br>Water softener |
| LIQUID PUMPS | Drive, packing & lubrication |
| MAN LIFT | Lubrication, adjustment, control function |
| DISTRIBUTORS | Cleanliness, adjustment, wear and lubrication (Turnheads-Verti Flo & Swing Flo) |
| SMALL SCALES | Test weigh<br>Cleaning, lubrication and test weight by qualified scale repairman (recommend maintenance agreement) |
| MOTOR TRUCK SCALE | Printer accuracy (relative needle reading)<br>Weight accuracy (relative other scales)<br>Free movement<br>Deck & pit cleanliness<br>Cleaning, lubrication and test weight by qualified scale repairman (recommend maintenance agreement) |
| BOB CAT & FORK LIFT | Operators and maintenance<br>Personal review<br>Operating manual and<br>Perform required service |
| MAINTENANCE TOOLS & EQUIPMENT | Condition & proper tools for jobs being performed |
| REPAIR PARTS INVENTORY | Type and number of replacement parts, adequate to support an effective preventative maintenance program. |

| | |
|---|---|
| PLANT EQUIPMENT | Plan equipment modification, replacement or additions which will reduce maintenance and operating cost. |
| BUILDING | Paint, concrete work, doors, roofs, adequate lighting, general appearance (PLAN IMPROVEMENTS) |
| BAG HOUSES/FILTER COLLECTORS | Differential pressure, socks, cages, spouting, air locks, and couplings |

## APPENDIX 1V: DRAFT CODE OF PRACTICE FOR GOOD ANIMAL FEEDING (FAO, 1998)

### Introduction

This code of practice applies to feed manufacturing and to the use of all feeds, other than those consumed while grazing free range. The objective of the code is to encourage adherence to Good Manufacturing Practice (GMP) during the procurement, handling, storage, processing (however minimal), and distribution of feed for food producing animals. A further objective is to encourage good feeding practices on the farm.

There are potential risks to human health associated with the contamination of feed with chemical or biological agents. This code outlines the means by which these hazards can be controlled by adopting appropriate processing, handling and monitoring procedures. The principle approaches required for assessing foodborne hazards to human health have been outlined elsewhere.[1*]

### General management

The ultimate responsibility for the production of safe and wholesome feed lies with the producer or manufacturer who should produce feeds with as low a level of hazard as possible and comply with any applicable statutory requirements.

The effective implementation of GMP protocols will ensure that:

- buildings and equipment, including processing machinery, will be constructed in a manner which permits ease of operation, maintenance and cleaning;
- staff will be adequately trained and that training is kept up to date;
- records will be maintained concerning source of ingredients, formulations including details and source of all additives, date of manufacture, processing conditions and any date of dispatch, details of any transport and destination;
- water used in feed manufacture is of potable quality;
- machinery coming into contact with feed is dried following any wet cleaning process;
- condensation is minimised;

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[1] Application of Risk Analysis to Food Standards Issues, Report of the Joint FAO/WHO Expert Consultation, Geneva, Switzerland. 13-17 March 1995 (WHO/FNU/FOS/95.3).

- sewage, waste and rain water is disposed of in a manner that ensures that equipment, ingredients and feed are not contaminated; and

- feed processing plants, storage facilities and their immediate surroundings are kept clean and free of pests.

**Raw materials of animal and plant origin**

Raw materials of animal and plant origin should be obtained from reputable sources, preferably with a supplier warranty. Monitoring of ingredients should include inspection and sampling of ingredients for contaminants using risk based protocols. Laboratory testing, where undertaken, should be by standard methods. Ingredients should meet acceptable, and if applicable, statutory standards for levels of pathogens, mycotoxins, herbicides, pesticides and other contaminants which may give rise to human health hazards.

In order to control the spread of specific pathogens it may be necessary to specify, for any given ingredient, the country and species of origin and any treatment process used prior to purchase. Care should be taken to preserve the identity of such material after procurement to facilitate any tracking that might be required.

**Minerals, supplements, veterinary drugs and other additives**

Minerals, supplements, veterinary drugs and other additives should be obtained from reputable manufacturers who guarantee the concentration and purity of ingredients and provide instructions for correct use.

**General management of feeds**

Feeds should be stored so as to prevent deterioration and contamination.

Processed feeds should be separated from unprocessed ingredients.

Containers and equipment used for transport, storage, conveying, handling and weighing should be kept clean.

Equipment should be 'flushed' with 'clean' feed material between batches of different formulations to control cross contamination.

Pathogen control procedures, such as pasteurization or the addition of an organic acid to inhibit mould growth, should be used where appropriate and results monitored.

Apart from feeds fed moist, such as silage and by-products of brewing, ingredients and feeds should be kept dry to limit fungal and bacterial growth. This may necessitate ventilation and temperature control.

Waste and unsaleable material should be isolated and identified, and only recovered as feed after freedom from hazardous contamination has been assured. Waste and unsaleable material containing hazardous levels of veterinary drugs, contaminants or any other hazards should be disposed of in an appropriate and, where applicable, statutory manner and not used as feed. If freedom from hazardous contaminants cannot be established, the material should be destroyed.

Packaging materials should be newly manufactured unless known to be free of hazards that might become feedborne.

Labels should be consistent with any statutory requirements and should describe the feed and provide instructions for use.

Feeds should be delivered and used as soon as possible after manufacture.

**Personnel**

All plant personnel should be adequately trained and should work to GMP standards.

The paper presents technical guidelines for good aquaculture feed manufacturing practice. The guidelines were compiled for FAO in support of Article 9 of the Code of Conduct for Responsible Fisheries (CCRF) concerning Aquaculture Development, and in particular in support of Article 9.4.3 of the CCRF concerning the selection and use of feeds and additives. The guidelines cover a number of issues, ranging from ingredient purchasing, processing, bulk storage, handling, monitoring and documentation, to issues such as employee training and safety, customer relations and the delivery of finished goods to the farmer. However, issues relating to the handling and management of manufactured aquaculture feeds by farmers on the farm are not covered here, as these will be considered within separate guidelines to be produced at a later date concerning good on-farm feed management practices.

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